Fuel Moisture, Seasonal Severity and Fire Growth Analysis in the US Fire Behavior Analysis Tools: Using Fire Weather Index (FWI) Codes and Indices as Guides in Alaska

1 Introduction

Efforts to conduct, interpret, and apply findings from fire growth analysis using the Wildland Fire Decision Support System (WFDSS) and Interagency Fuel Treatment Decision Support System (IFTDSS) tools are heavily dependent on weather observations and forecasts from local weather stations and landscape fuel classifications from LANDFIRE.

Additionally, analysts apply a considerable number of subjective inputs to their analyses, such as Initial Fuel Moisture values for live and dead fuels, best weather station to use for wind and fuel moisture assessments, crown fire potential and manifestation, and spotting frequency.

The typical approach utilized by analysts when initializing their first analyses is to use default inputs as much as possible and "calibrate" the model to know fire growth events. This method can be time consuming, assumes that the fire has already experienced one or more significant growth events, and sometimes leads analysts to adjust factors that may not be responsible for changes observed on the ground.

This guide offers recommendations for using Canadian Forest Fire Danger Rating System (CFFDRS) fuel moisture codes and fire behavior indices from the Fire Weather Index (FWI) system to provide objective guidance for initial settings for many of these analysis inputs. The FWI system has been formally calibrated for northern boreal ecosystems and effectively identifies significant thresholds for the Alaska landscapes as well as important trends in changing fire growth potential.

The primary tools considered here include WFDSS and IFTDSS analyses. Included are Short-term Fire Behavior (STFB) that is based on the FLAMMAP fire growth modeling system, Near-Term Fire Behavior (NTFB) based on the FARSITE fire growth modeling system, and Fire Spread Probability (FSPro) based on FLAMMAP and NFDRS inputs using FireFamily Plus within WFDSS. IFTDSS uses primarily FLAMMAP tools for its fire growth analyses.

All analyses use fuel moisture scenarios including 1hr, 10hr, 100hr, Woody, and Herbaceous fuel moistures. Analysts are encouraged to edit these settings in general, or for specific fuel classes. FSPro utilizes wind climatology from a selected weather observing location and allows the user to make both coarse and fine adjustments to that distribution. FSPro is heavily dependent on the Energy Release Component for fuel model G (ERCg) to identify daily fuel moisture and spotting scenarios for both deterministic (forecast) and probabilistic (climatology) portions of the analysis. Analysts are finding that they need to edit the ERC classes and streams heavily to reflect expected conditions. At the very least, these daily FWI fuel moisture codes and fire behavior indices are a useful cross-references when considering analysis inputs and outputs.

There are two sections that follow.

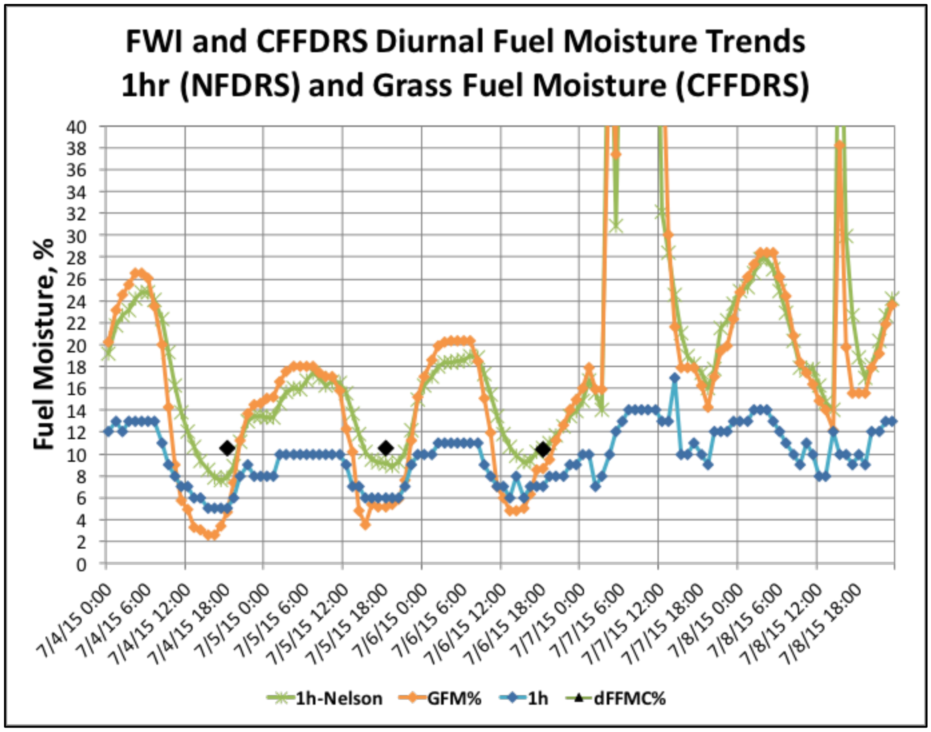
- The first is a discussion of the FWI fuel moisture codes, their fuel moisture equivalents, and how they can be used to facilitate edits to fuel moisture scenarios so that they reflect current observed conditions.
- The second shows how Buildup Index (BUI) and Fine Fuel Moisture Code (FFMC) can be used to inform ERC Class Tables and Streams to reflect current season severity and facilitate local "burn days" climatology to the analysis.

2 Fuel Moisture Inputs and FWI Fuel Moisture Codes

2.1 Fine Dead (1-hour) Fuel Moistures

While live fuel moistures (Woody and Herbaceous) have large impacts on the fire spread models, they are fixed over the duration of both WFDSS and IFTDSS analyses. The most variable fuel moisture input is the 1-hour fuel moisture. WFDSS STFB and NTFB use hourly weather data as well as slope, aspect, and shading factors to “condition” 1-hour (and 10-hour) fuel moisture values from initial settings.

This diurnal plot of fine dead fuel moisture illustrates the effect of hourly weather. Included are the original Fosberg (1971) model (1h) in blue, the-Nelson (2000) model (1h) in green, and the Wotton (2009) Grass Fuel Moisture (GFM%) in orange. Notice that both 1h-Nelson and GFM% show greater responsiveness to overnight recovery and precipitation events. However, the 1h-Nelson estimate reflects a 2-4% increase in the estimate during the dry burn periods.



Assuming the GFM% estimate is more compatible with existing fire spread models and more responsive to day-to-day variation responsible for changing fire spread, the analyst could consider adjusting the 1-hour fuel moisture estimate based on online evaluations or this table.

Keep in mind that NTFB uses conditioned 1-& 10-hour fuel moistures throughout the analysis. Consider using STFB where possible and setting “conditioning” days to 0.

Grass Fuel Moisture

- Based on research done in savanna grasses in Ontario
- Table shows Equilibrium Moisture Content
- Assumes that atmosphere unchanged for 2-3 hours.

CFFDRS Grass Fuel Moisture		Relative Humidity (%)							
SOL_{ef}	Temp	10%	20%	30%	40%	50%	60%	80%	100%
Overcast Or Shaded	41°F	10	13	16	17	19	21	25	38
	50°F	9	12	14	16	17	19	23	37
	59°F	8	11	13	15	16	17	23	37
	68°F	7	10	12	13	15	17	21	34
	77°F	6	8	10	12	14	15	20	32
	86°F	5	7	9	11	12	14	19	32
Broken, Clouds > 50% of sky	41°F	7	10	12	14	15	16	19	21
	50°F	6	9	11	13	14	15	17	20
	59°F	6	8	10	11	13	14	16	19
	68°F	5	7	9	10	12	13	15	17
	77°F	4	6	8	9	10	11	14	17
	86°F	3	5	6	8	9	10	13	16
Scattered Clouds < 50% of sky	41°F	5	8	10	11	12	13	15	17
	50°F	5	7	9	10	11	12	14	15
	59°F	4	6	7	9	10	11	13	14
	68°F	4	5	6	8	9	10	11	13
	77°F	3	4	5	6	7	8	10	12
	86°F	2	3	4	5	6	7	9	11
Clear Skies	41°F	4	6	7	8	9	10	12	13
	50°F	3	5	6	7	8	9	11	12
	59°F	3	4	5	6	7	8	9	11
	68°F	3	4	4	5	6	7	8	10
	77°F	2	3	4	4	5	6	7	9
	86°F	2	2	3	3	4	5	6	7

2.2 10-hour Fuel Moisture

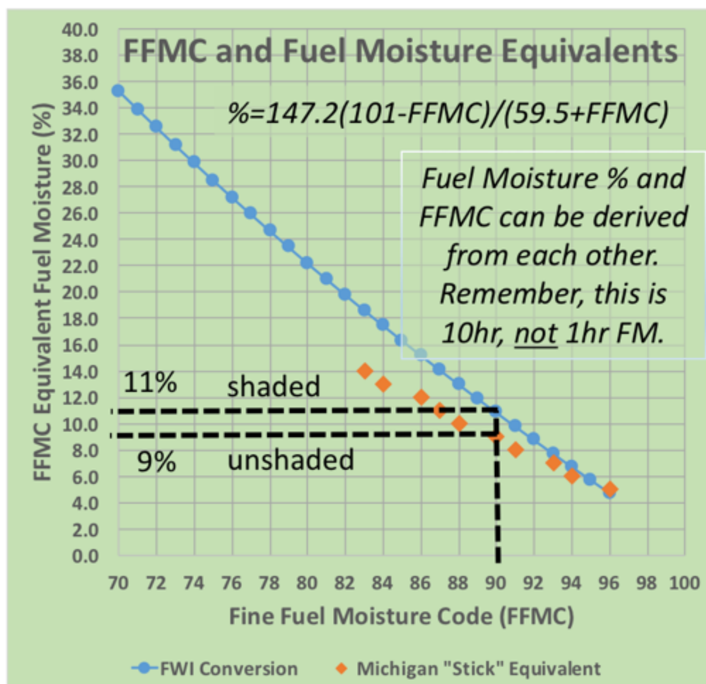
While the 10-hour Fuel Moisture exerts less influence on the Rothermel Fire Spread model outputs, it is estimated for each analysis and is also subject to the influence of the Nelson Dead Fuel Moisture model's tendency to raise moisture estimates.

In addition, the FWI Fine Fuel Moisture Code (FFMC) is very like a 10-hour timelag fuel moisture, estimated by FWI developers as somewhere between a 5- and 16-hour timelag. Though produced as a "unitless" code, it is easily converted to a fuel moisture, representing an estimate of shaded litter fuels under forest canopy. As such, it assumes that slope, aspect, and variation in shading is less significant than the drying effects of temperature and humidity.

In fact, while 1-hour estimates were discussed above, fine dead litter fuels and feathermoss fuel beds under the boreal forest canopy may respond to weather conditions much more like FFMC and may be appropriately set equal to the 10-hour estimate described here.

FFMC and Timelag Fuel Moisture

- FFMC represents shaded litter fuels with about a 10 hr timelag (5 to 16 hrs)
- An equivalent fuel moisture % can be estimated and used in predictions.



FFMC	96	95	94	93	92	91	90	89	88	87	86	85	84	83	82	81	80
10h-Sh	5	6	7	8	9	10	11	12	13	14	15	16	17	19	20	21	22
10h-Unsh	5		6	7		8	9		10	11	12		13	14		15	

Based on 20 years of daily estimates of FFMC values, its 10hr fuel moisture equivalent, and manual estimate of NFDRS unshaded 10hr "Sticks" in Michigan 1975-1995.

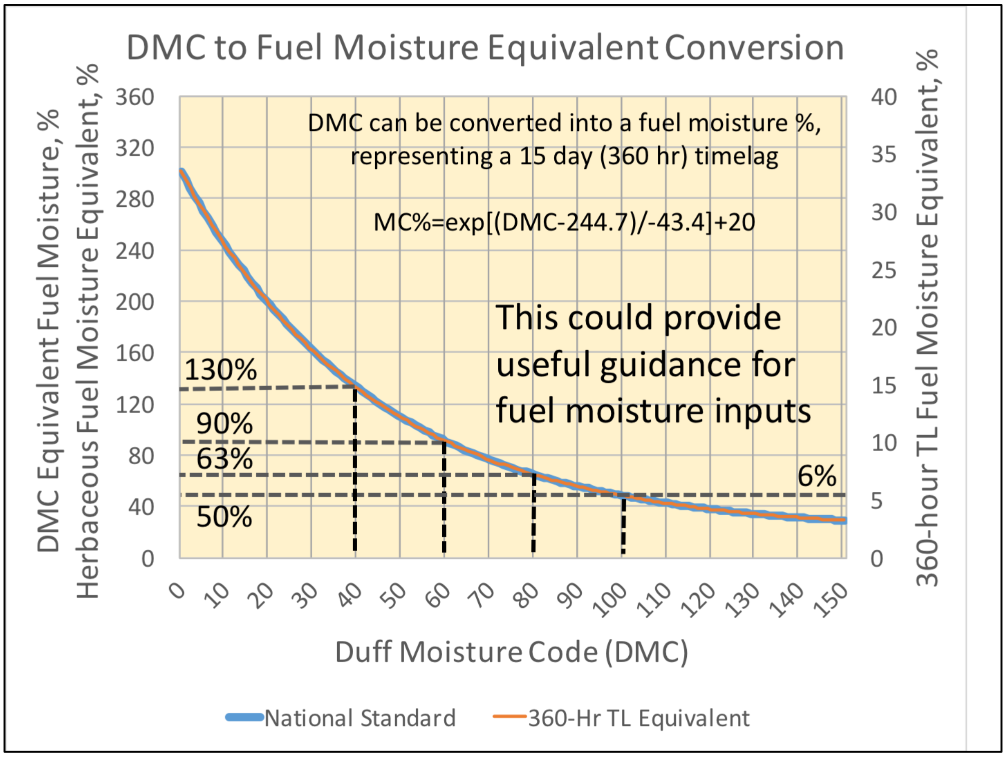
This graph and table depict the relationship between the estimated FFMC and prospective 10-hour fuel moisture equivalents. On the graph, the blue points reflect the formula used in the FWI system to convert between code and fuel moisture content (%). 10-hour fuel moistures derived in this way represent shaded forest litter dead fuel moisture. In the table and on the graph, in orange is the conversion between measurements of fuel moisture ***unshaded*** NFDRS "sticks".

2.3 Slowly Responding Fuel Moistures

WFDSS and IFTDSS analyses both include a wide range of fuel moisture estimates that respond more slowly over weeks and months during the fire season. 100-hour and 1000-hour fuel moistures range from a 4- to 40-day timelag in heavier dead fuels. Live fuel moistures, herbaceous and woody, are used to account for the influence of lush green vegetation as a heat sink in the fire environment.

Currently, there is little observed data to inform the inputs for fuel moisture and flammability conditions for these live fuels found in Alaska. Despite this, many analysts use these inputs as their primary tool in calibrating fire growth models against observed fire spread.

The FWI Duff Moisture Code (DMC), a "unitless" index of an assumed intermediate "timelag" fuel moisture, takes a different approach. It integrates fuel moisture conditions across this broad range of available fuel characteristics (other than fine dead fuels) and represents availability and flammability in those classes more generally. It has been calibrated to drying in the duff layer below litter on the forest floor.



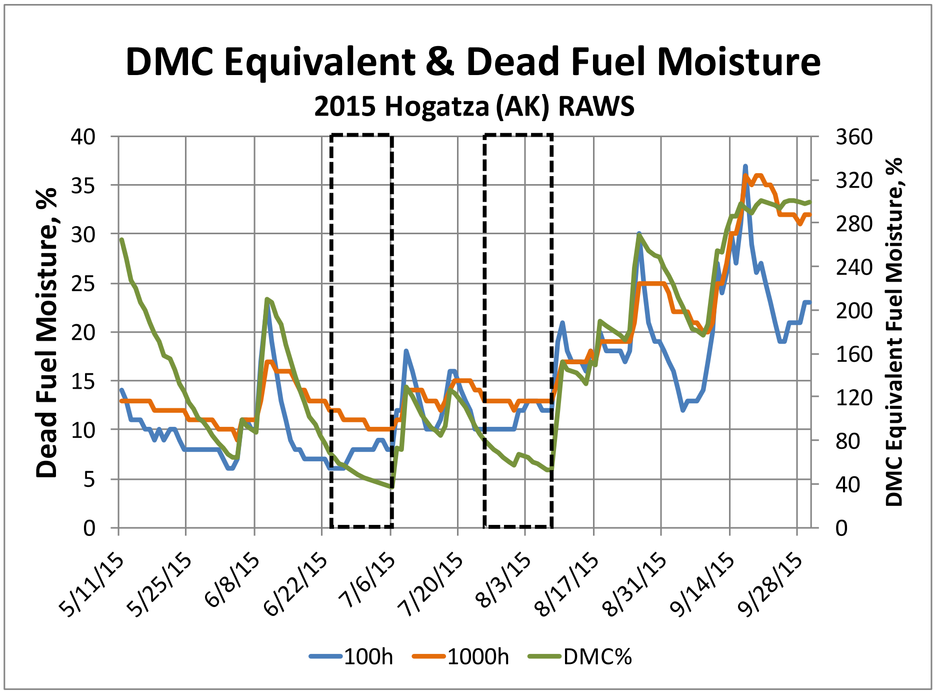
This graph depicts the relationship between the daily estimate of DMC and its equivalent duff fuel moisture, in percent. Further, it depicts a conversion to fuel moisture estimates of an above-ground dead fuel of approximately 5" diameter. DMC estimates are available for nearly 200 weather observing locations across Alaska. These represent objective characterizations that can be used to adjust and apply fuel moisture inputs for analysis purposes.

Only the relationship between DMC and its equivalent duff fuel moisture % has been rigorously evaluated. Recommendations for estimating 100-hr and Herbaceous fuel moisture can be applied for analysis purposes, but should be evaluated critically. ***Feedback concerning these methods should be directed to the Alaska Wildfire Coordinating Group's (AWFCG) Fire Modeling and Analysis Committee (FMAC) or the Alaska Fire Science Consortium (AFSC).***

2.3.1 100-hour Fuel Moisture

In the graph above, DMC can be converted to a duff fuel moisture equivalent that represents a 360 hour timelag trend. This should be intermediate between 100-hour and 1000-hr timelags.

This example season plot from 2015 at the Hogatza RAWS demonstrates trends for these three fuel moistures. The DMC Equivalent "duff" fuel moisture was rescaled to overlay the 100-hour and 1000-hour trends. The DMC moisture trend is, in fact, intermediate between the 100- and 1000-hr trends, representing a 360 hr timelag fuel moisture trend.



Using the 360-hour fuel moisture estimated from the DMC conversion graph above, the 100-hour and 1000-hr fuel moistures can be estimated as slightly lower and higher. In this example, on July 6th, the 100-hr could be adjusted to be more like the DMC's 360-hr estimate, between 4 and 5%.

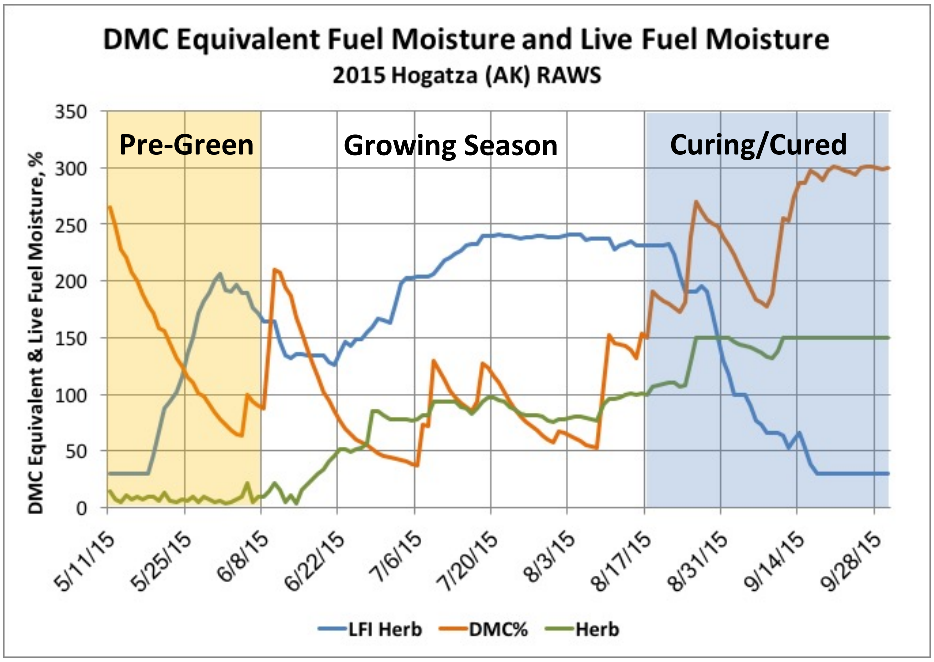
2.3.2 Herbaceous Fuel Moisture

Herbaceous fuel moisture has become a critical input for fire growth analysis in WFDSS and IFTDSS. But instead of faithfully obtaining and using estimates of moisture content, this input is used as a calibration tool for adjustment of fire spread estimates in those analyses. It works principally by triggering a fuel load transfer between herbaceous loads and fine dead loads for many of the fuel models currently used. Transferred loads would then take on the 1-hr fuel moisture estimate. However, along with woody fuel moisture, these loads and their elevated fuel moistures also impose important heat sinks during the growing season, muting simulated fire spread within the models.

Despite little observation data to support input values in many cases, herbaceous fuel moisture estimates used in analyses can have a large influence on results. And once the value is set, its influence is fixed for the duration of that analysis. Assuming that the herbaceous fuel moisture will remain fixed over a 1-14-day analysis duration may be accurate or problematic; we cannot be sure. Even so, making large adjustments in this value to calibrate to a known growth event may not effectively represent the factors responsible for day-to-day variation in fuel availability and flammability within the models. Modeled spread calibrated to observed fire spread based primarily on sensitivity to live fuel moisture estimates will produce inconsistent results when the assumptions are applied to forecast conditions.

The methods described here assume that the DMC equivalent duff moisture % is a good proxy for growing season herbaceous fuel moisture inputs responsible for guiding fuel load transfers and estimating heat sink factors for analyses. This would allow analysts to evaluate current DMC values in the fire area, view DMC forecast trends, and objectively apply herbaceous fuel moisture inputs.

Using the DMC to fuel moisture equivalent conversion on page 4, current and/or forecast DMCs in the fire area can be converted to DMC equivalent fuel moisture for use directly (or as a guide) for the herbaceous fuel moisture input to the fire simulation analysis.



In the example plot shown here, DMC equivalent fuel moistures based on weather inputs from the Hogatza RAWS in 2015 are compared to LFI-based and 1000-hr based herbaceous fuel moisture estimates.

First, DMC equivalent fuel moistures cannot be used to estimate pre-green and curing/cured states in the fall. These areas are shaded out on the graph. In those cases, estimates of herbaceous fuel moisture should reflect curing/cured conditions.

From June 8th through July 6th, DMC equivalent fuel moisture estimates fell from a high of 200% to 45%. Estimates, suggested on the graph ranging from 45% to 75% during the 15 days beginning June 22nd, would impose significant fuel load transfers and enhance fire behavior predictions precisely when dry fuel conditions was supporting extreme fire growth events. Through the middle of July, there was a lull in significant fire events in this area and DMC fuel moisture estimates were between 90% and 130%, reducing and eliminating fuel load transfers and increasing the heat sink live fuels provide. For several days in early August, fires in the Hughes area became active and made several significant runs. DMC fuel moisture estimates during this period would have been between 50% and 60%.

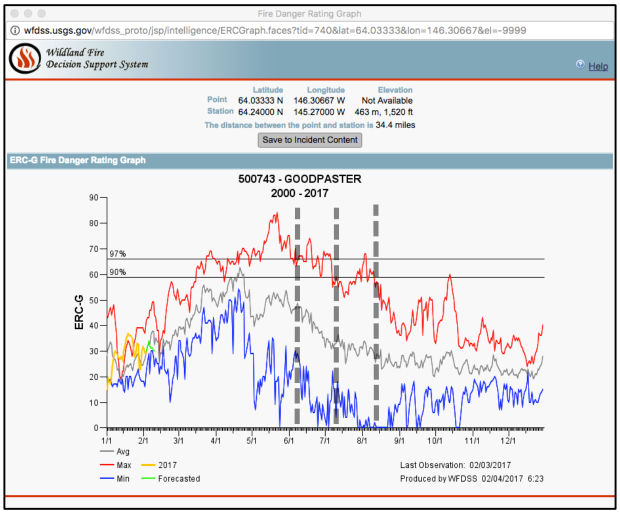
None of this suggest that this is the phenological trend of moisture content in herbaceous fuels during the growing season in Alaska. But it would be difficult to obtain satisfactory simulations using herbaceous fuel moistures between 135% and 240% as estimated by the LFI based moisture model. In fact, most analysts heavily edit the live fuel moistures for most of their analyses during the growing season.

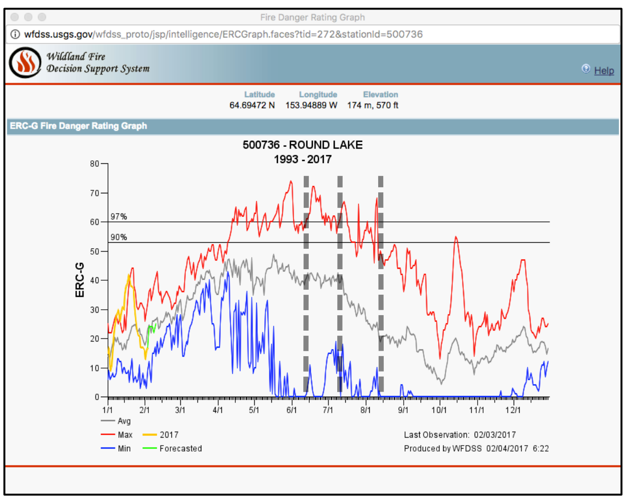
2.4 Fuel Moisture Climatology for FSPro

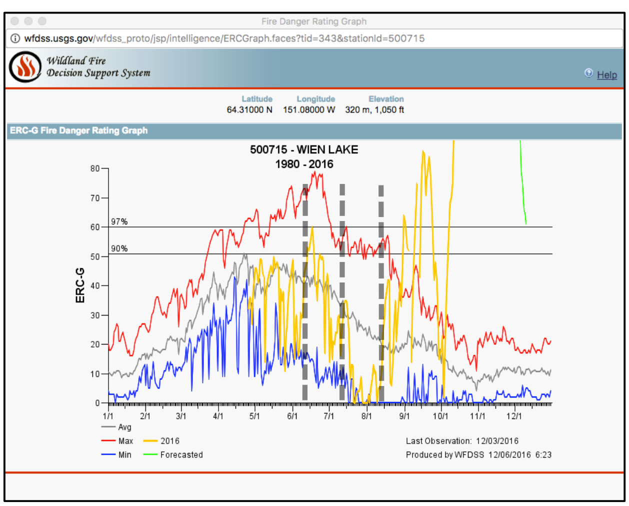
1-hr	10-hr	100-hr	Herbaceous	Woody
ERCg climatology tends to mute the observed variation in fine fuel moisture. consider lowering 1-hr in top two bins, possibly to 3% or 4%.	Not a large factor in spread model. Consider FFMC climatology as a default (6-7%, 8%, 9%, 12%, 15%.	Again, generally small influence. DMC climatology suggests defaults of 6%, 7%, 8%, 12%, and 17%.	Use current DMC estimate and forecast/outlook to suggest range of DMC values expected over analysis period. Use fuel moisture conversion and spread range over ERC classes.	Review NFMD records for Black Spruce needle moisture, generally <100%. Others shrubs generally higher during growing season.

3 Fire Season Severity and FSPro ERC Classes and Streams

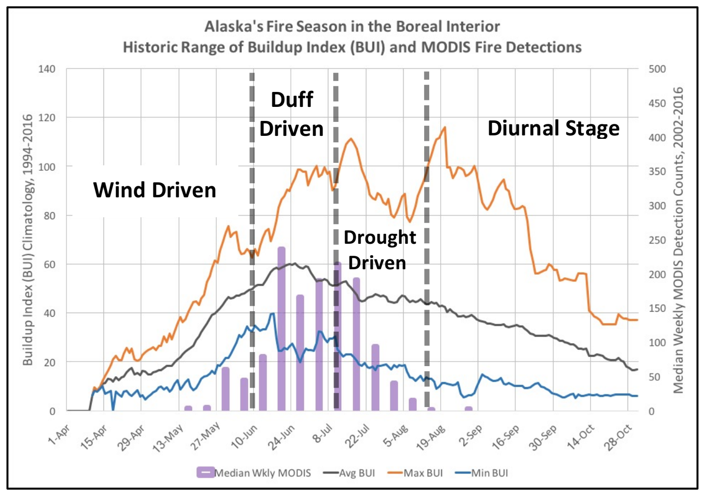
3.1 Energy Release Component (ERC) and Buildup Index (BUI) as Season Indicators







To the left, these three fire danger ratings graphs from WFDSS depict annual ERCg climatology for observing locations in the western, central and eastern interior. Along with these, the single BUI season graph below shows climatology for all the interior with median weekly MODIS detections representing area burned during the season. Gray dashed lines highlight the divisions between the fire "seasons"(Wind-Driven, Duff Driven, Drought Driven, Diurnal Stage) on all four graphs. The precise dates of the divisions vary from season to season and are less important than the ERC and BUI trends through each of these seasons.



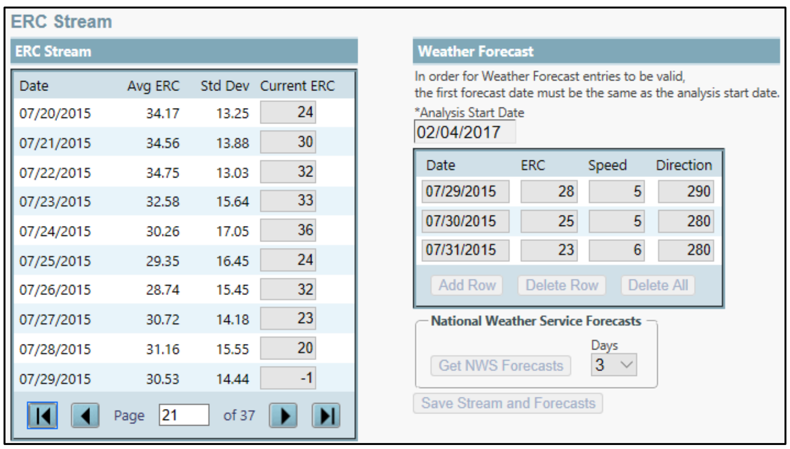
The MODIS detections confirm that the BUI trends correctly represent the "Duff Driven" and "Drought Driven" seasons as peak seasons. There is lesser overall area burned in the "Wind Driven" and "Diurnal Stage" shoulder seasons.

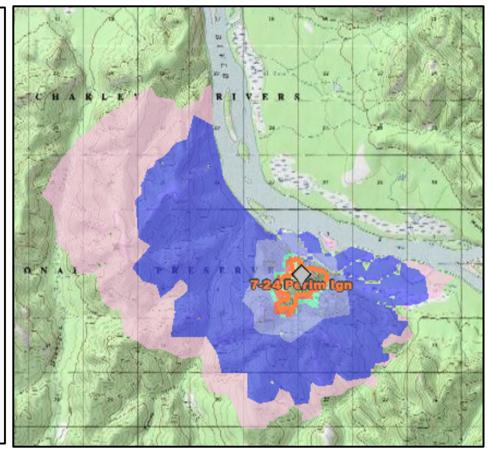
The corresponding ERCg seasonal trends under-represent seasonal potential for the "Duff Driven" and "Drought Driven" seasons, with the average (gray) trend peaking very early in the "Wind Driven" shoulder season and showing steady decline throughout the peak seasons. This skewed representation of seasonal trend is the result of the fuel load transfers from the herbaceous category to fine dead fuels during the early, pre-green period and the large heat sink provided by elevated herbaceous and woody fuel moistures during the growing season. While this modeled heat sink characterization works well for many landscapes, it inaccurately diminishes potential during these peak seasons in northern conifer forests.

ERCg performs several critical functions in the FSPro analysis. First, as a default, it provides a frequency distribution of 5 fuel moisture and fire behavior scenarios based on its whole season climatology. Second, that climatology provides day-to-day streams of those fuel moisture and fire behavior scenarios to model fire spread probabilities weeks into the future. The process explained below will demonstrate how knowledge of observed FWI elements can inform adjustments to both the frequency distribution and the ERCg streams used in those analyses.

3.2 Editing the ERC Stream to Reflect FFMC and BUI Trends

In FSPro analysis, the ERC Stream is displayed as a sequence of days in the recent past and the estimated ERCg values for those days. A forecast stream, based on the National Digital Forecast Database (NDFD) weather forecast, can be included. And after those days, climatology approaching the average ERCg trend provides a range of ERC sequences further into the future for the analysis period.





In this example, with the minimum burnable ERCg value at 38, all of the observed and forecast ERC stream falls below that threshold. Given that, the map shows the result, with a very low probability of any significant fire spread. That may be correct in this case, but with ERCg exaggerating the influence of live fuels, it may be a serious underestimate.

Setting ERCg Levels for FSPro Analysis

80 to 82.9	83 to 85.9	86 to 88.9	89 to 91.9	92+	FFMC / BUI
5th Bin	4th Bin	2nd Bin	2nd Bin	Top Bin	110+
5th Bin	4th Bin	2nd Bin	2nd Bin	Top Bin	90 to 109.9
5th Bin	4th Bin	3rd Bin	3rd Bin	2nd Bin	60 to 89.9
5th Bin	4th Bin	4th Bin	3rd Bin	3rd Bin	40 to 59.9
5th Bin	5th Bin	4th Bin	4th Bin	3rd Bin	< 40

%ile		Min ERC
96	Top	61
89	2nd	54
76	3rd	49
67	4th	43
58	5th	38

Use FFMC and BUI to adjust/set ERC values in ERC stream, both observed & forecast

Accurately portraying the observed and forecast ERC stream are critical to the accuracy of FSPro output. It is possible to use FFMC and BUI from the FWI system to adjust the ERC stream when preparing initial analyses. The table to the left shows FFMC and BUI classes and suggests how they are combined to identify where in the ERC frequency distribution each day falls.

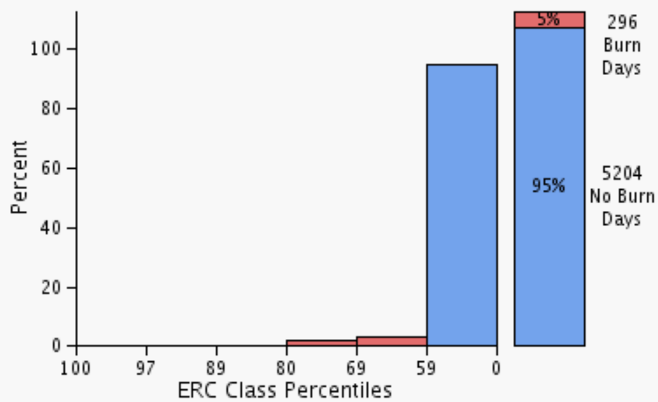
Analysts should evaluate ERC values using FFMC and BUI values observed from representative local weather stations and find the cell that represents that combination of values. ERCg levels can be derived from the class level the table suggests.

For example, if the FFMC is 91 and the BUI is 80, the combination suggests that the ERC value should be in the third ERC Class, with a value between 49 and 53. Because 91 and 80 are both intermediate within their classes, the ERC might be best represented as 51 or 52. Consider estimating ERC values for up to 3 days in the observed ERC stream and all the forecasted ERC values before conducting the initial FSPro analysis.

3.3 Evaluating and Editing ERC Class Table using "Burn Days" Climatology

To continue with the example above, this ERC Class Burn Days Summary shows the result. ERC Climatology with the default ERC stream produced only about 300 burnable days among 7000 total days, less than 5%. ***That amounts to one burn day in 3 weeks***. These days all came in the lowest two classes representing moderated burning conditions. In fact, there are frequent instances in the historic record where drying conditions around active fires increased the risk of spread in much less than two weeks.

ERC Class Burn Days Summary

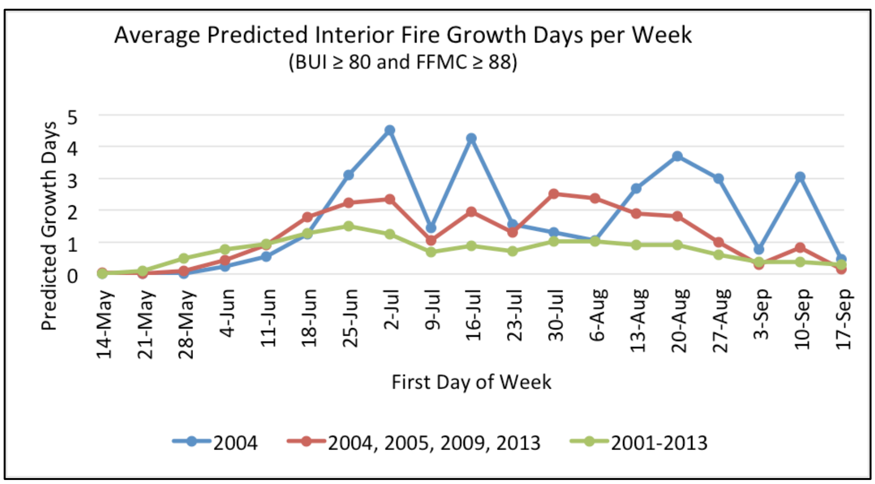


%ile	Min ERC	Burn Days	%
97	61	0	0
89	54	4	0
80	49	19	0
69	43	83	2
59	38	190	3
		296	5

5204 No-Burn Days (95%)
500 fires X 11 non-forecast days = 5500 days
The summary does not include the 3 forecast days

Though fire spread potential in boreal landscapes may not respond as the ERCg suggests during the peak seasons, there is an observed episodic character to fire spread with fires lying dormant for days and then growing aggressively after a short transition. This suggests an influence of the heat sink in live fuels.

This graphic, based on analysis of FFMC and BUI trends in combination with concurrent observed MODIS detections highlights an average frequency of burn days under a range of fire seasons. Overall, it suggests 1-2 days of active spread potential per week, or 15-30% of all days in an analysis period for peak season. For more active seasons, that percentage may rise to 40% (3 days) or more overall.

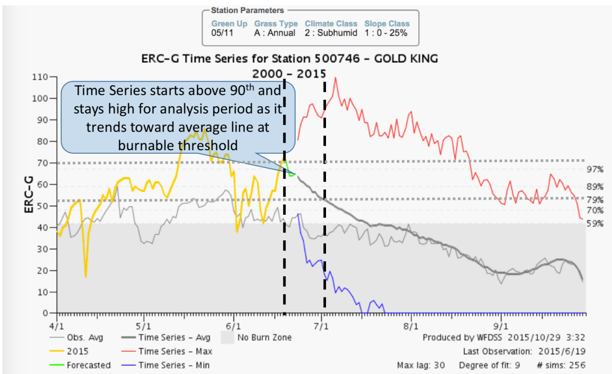


With verified ERC Streams, initial FSPro analyses for a given start date and duration will suggest a distribution of burn days produced by the climatology. The analyst should review that frequency distribution and make edits to reflect the climatology demonstrated here and the forecast and outlook guidance available. Methodologies are suggested below.

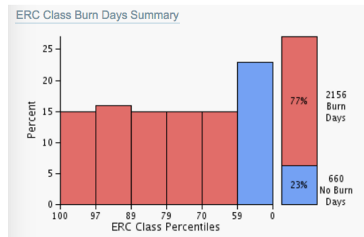
3.3.1 Duff Driven Season: Too Many Burn Days

In this common example during the peak season surrounding the summer solstice, ERCg level is only beginning to fall from its pre-green peak levels. Overall, the analysis assumed that 82% of all days were burn days, nearly 6 days a week overall. There is little evidence to support this frequency of significant growth even in extreme seasons. There may be individual periods with 6-7 days with daily significant spread, but nothing that suggest that for an overall average.

ERCg Time Series for Kobe & Fish Creek
for June 20, 2015



Burn Days Summary for Kobe & Fish Creek



%ile	Min ERC	Burn Days	%	
97	67	433	15	3%
89	59	460	16	8%
79	53	434	15	10%
70	48	410	15	9%
59	42	419	15	11%
		2156	77	40%

660 No-Burn Days (23%)
256 fires X 11 non-forecast days = 2816 days
The summary does not include the 3 forecast days

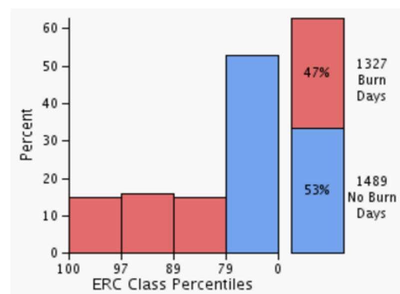
Date	ERC	Speed	Direction
06/21/201	64	10	260
06/22/201	64	8	280
06/23/201	65	10	270

Add Row Delete Row Delete All

With three forecast days having ERCg above 90th threshold, an average of about 11.5 burn days (82%) in the 14-day analysis period.

Is that too much?

Adjustments in the ERC stream may alter this distribution of burn days significantly, but assume that the stream has already been edited as recommended above. Reducing the frequency of burn days can be accomplished easily by reducing the number of ERC classes. In this case, eliminating the lower two classes reduced the frequency from 77% to 47%. This, in effect, is modeling the resistance from the heat sink in live fuels.

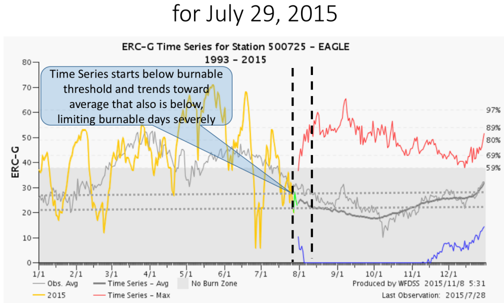


3.3.2 Drought Driven Season: Not Enough Burn Days

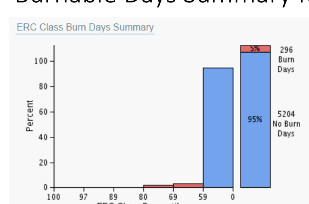
This corresponding example from later in the season highlights the difficulty ERCg has in representing fuel availability and flammability at that time. Current ERCg levels are well below burn day thresholds, and the analysis will produce very few active burn days as a result. Given the guidance for burn day climatology above, it would be prudent to suggest at least 15% burn days over 2 weeks. In fact, if a significant drying trend is forecast, frequency of 30-40% may be an appropriate frequency.

Adding a 6th ERC Class will produce additional burn days. But if that is insufficient, editing the ERC Stream even further may be necessary.

14 day ERCg Time Series for Trout Fire
for July 29, 2015



Burnable Days Summary for Trout Fire



%ile	Min ERC	Burn Days	%	
97	61	0	0	3%
89	54	4	0	8%
80	49	19	0	9%
69	43	83	2	11%
59	38	190	3	10%
		296	5	40%

5204 No-Burn Days (95%)
500 fires X 11 non-forecast days = 5500 days
The summary does not include the 3 forecast days

Date	ERC	Speed	Direction
07/29/2015	28	5	290
07/30/2015	25	5	280
07/31/2015	23	6	280

Add Row Delete Row Delete All

With no forecast days having ERCg above threshold, an average of about ½ burn days (4%) in the 14-day analysis period.

Is that enough? On July 29, 2015?

4 Conclusion

These recommendations are prepared specifically for spatial analysis in Alaska, with emphasis on its boreal landscapes. There may be sufficient applicability in the Western Great Lakes Forest of Michigan, Minnesota, and Wisconsin to consider similar approaches. These guidelines are based on fire potential reflected during the growing season in northern forests with significant live fuel admixtures both on the surface and in the canopy. They do not have applicability for curing and cured fuelbeds that represent peak season conditions throughout much of the western US.

The goal of these recommendations is to emphasize real observed conditions as inputs to the model, to identify where in the models real variations of fire behavior and fire spread phenomenon are best reflected, and to minimize the need for using calibrating factors that may not reflect the most frequently changing factors that drive day-to-day variation in fire behavior. Many of the recommendations include use of CFFDRS Fire Weather Index system codes and indices. Recent, current, and forecast values and trends can be explored at http://akff.mesowest.org. Up to 3 forecast days are now available for use.

Further, this approach assumes that nearly all significant growth occurs on fewer days with more flammable conditions that encourage fires to overcome the heat sink of the live fuels. Using this approach to reduce the frequency of burn days in FSPro and reduce or eliminate individual burn days in ERC streams or in NTFB sequences requires a concurrent commitment to model crown fire potential in the conifer fuels, especially in Black Spruce. Analysts use two approaches to accomplish this:

- Earlier in the growing season when hardwood and mixedwood forests have greater live fuel heat sinks to discourage spread, crown fire in Black Spruce can be encouraged by converting the standard fuel models, tu3/163 (timber/grass/shrub) and/or tu4/164 (dwarf conifer) to sh5/145 (chapparal). Fuel loadings are comparable, and it effectively models individual growth events with observed environmental inputs.
- Later in the peak season (drought-driven), when live fuels may be more stressed across the landscape, hardwoods and mixedwood forests may be more available and flammable fuelbeds. In this case, selecting the Scott & Reinhardt Crown Fire method produces crown fire across the wider spectrum of fuel models distributed across the landscape. In this case, it may be unnecessary to convert tu3/163 and/or tu4/164 fuel designations.
- As a caution, when using tu3/163 and tu4/164 to represent black spruce communities or a variety of grass and grass/shrub models for tundra landscapes, keep in mind that moisture of extinction is as low as 12%. Under the influence of fuel moisture conditioning, there will be numerous instances that analyses will produce elevated 1hr- and 10h- fuel moistures that come under the dampening influence of that low moisture of extinction. This is especially problematic in NTFB where there are no settings to mitigate its effect. There is some facility to do that in STFB where the analyst can select 0 (zero) conditioning days and simply use initial fuel moisture inputs. This can produce acceptable results for surface fuels under forest canopy and in open flat tundra, where conditioning factors are minimized on the ground.

These recommendations should help produce effective analyses early in an incident without any significant calibration. However, as the fire develops a history of growth events, perceivable variability in weather influences, and an accumulation of fireline observations it is appropriate to critically evaluate these guidelines. Your experience using them and recommendations for changes are important. Contact the Alaska Wildfire Coordinating Group's (AWFCG) Fire Modeling and Analysis Committee (FMAC) or the Alaska Fire Science Consortium (AFSC) if there are contributions to offer.

5 References

Wildfire Assessment Websites:

Maps/Imagery/Geospatial Services: https://fire.ak.blm.gov/predsvcs/maps.php

Weather: https://fire.ak.blm.gov/predsvcs/weather.php

Fuels/Fire Danger: https://fire.ak.blm.gov/predsvcs/fuelfire.php

Air Quality: https://fire.ak.blm.gov/predsvcs/airquality.php

Outlooks: https://fire.ak.blm.gov/predsvcs/outlooks.php

Fire Weather Index (FWI): http://akff.mesowest.org

NWS Alaska Fire Weather: http://w2.weather.gov/arh/fire

NWS National Fire Weather: http://www.srh.noaa.gov/ridge2/fire/

Alaska Climate: http://climate.gi.alaska.edu/

NIFC Fire Enterprise Geospatial Portal (EGP): https://egp.nwcg.gov/egp/default.aspx

Wildland Fire Decision Support System: http://wfdss.usgs.gov

Wildland Fire Library: https://firelibrary.org/

Guides

Alaska Fuel Model Guide (draft update, 2016 and original, 2008):
https://www.frames.gov/files/9614/6482/3097/Revised_FuelModelGuide_Draft_May2016_Posted.pdf
https://www.frames.gov/files/2814/3352/8200/Alaska_Fuel_Model_Guidebook_0620081.pdf

FSPro Analysis in Alaska
https://www.frames.gov/documents/alaska/docs/FSProAnalysisAK_V1.1_Mar_2012.pdf

Field Guides to CFFDRS Fire Weather Index (FWI) and Fire Behavior Prediction (FBP) Systems:
https://www.frames.gov/files/3014/2309/6588/AK_FireWeatherIndex_FieldGuide_2015.pdf
https://www.frames.gov/files/6914/2309/6585/AK_FireBehaviorPrediction_FieldGuide_2015.pdf

Fire Ending Event Workshop:
https://www.frames.gov/files/1513/8749/6485/AWFCG_2008_Fire_Ending_Event_Workshop.pdf

How to download AK fire perimeters from AICC
https://drive.google.com/file/d/0Byauxp0C04_femRBVERlWlF6SHc/view?usp=sharing

Analysis Naming Convention in Analyst info folder
https://drive.google.com/file/d/0Byauxp0C04_fZGJ4d1Rfa2JsLXc/view?usp=sharing

Other Web Resources

Alaska Fire Science Consortium Fire Modeling Resources:
https://www.frames.gov/partner-sites/afsc/partner-groups/fire-behavior-modeling-group/

CFFDRS YouTube Learning Resources:
https://www.youtube.com/playlist?list=PLriyD21WeCtKRA2TsWwrInsRmuC0j86HG

Growing Season Index and Live Fuel Moisture:
https://www.wfas.net/index.php/growing-season-index-experimental-products-96

Alaska Fire Modeling Workshop (2012):
https://www.wfas.net/index.php/growing-season-index-experimental-products-96

KMLs:

Active Fire Mapping KML Bundle: https://fsapps.nwcg.gov/afm/data/kml/alaska_latest_AFM_bundle.kml

AICC Active Fire Bundle: https://afsmaps.blm.gov/imf/sites/help/AlaskaWildfires.kml

Avenza Maps Products

AFS PDF Maps: https://fire.ak.blm.gov/predsvcs/geopdf.php

DOF PDF Maps: https://sites.google.com/site/alaskafiremaps/home

Reports, Presentations and Publications

Carlson, J.D. et.al. 2007. Application of the Nelson model to four timelag fuel classes using Oklahoma field observations: model evaluation and comparison with National Fire Danger Rating System algorithms. International Journal of Wildland Fire, 2007, 16, 204–216

Fosberg, M. A., and J. E. Deeming. 1971. Derivation of the 1- and 10-hour timelag fuel moisture calculations for fire-danger rating. Research Note RM-207. Fort Collins, CO, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station.

Jolly, William M., Nemani, R. and Running, S.W. 2005. A generalized, bioclimatic index to predict foliar phenology in response to climate. Global Change Biology 11(4):619 – 632.

Kidnie, S.K., Wotton, B.M. and Droog, W.N. 2010. Field guide for predicting fire behaviour in Ontario's tallgrass prairie. Elgin County Stewardship Council Special Publication. Ontario Ministry of Natural Resources, Aylmer, Ontario. 65 p.

Miller, Eric A. 2009. Fire Indices for FSPro in Alaska: A comparison of ERC and BUI on the 2009 Titna River Fire (420). Unpublished Report.

Nelson, Ralph M, Jr. 2000. Prediction of diurnal change in 10-h fuel stick moisture content. Canadian Journal of Forest Research 30, 1071–1087. doi:10.1139/CJFR-30-7-1071

Wotton B.M. 2009. A grass moisture model for the Canadian Forest Fire Danger Rating System. Paper 3-2 in Proceedings 8th Fire and Forest Meteorology Symposium. Kalispell, MT Oct 13-15, 2009

Ziel, Robert, Wolken, Jane, St. Clair, Thomas, and Henderson, Marsha. 2015. Modeling Fire Growth Potential By Emphasizing Significant Growth Events: Characterizing A Climatology Of Fire Growth Days In Alaska's Boreal Forest. Extended Abstract for presentation at the AMS 11th Symposium on Fire & Forest Meteorology. May 5th, 2015 (https://ams.confex.com/ams/11FIRE/webprogram/Paper272864.html).